NASA PLUM BROOK

&

GLENN RESEARCH CENTER

BAT SURVEY
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Introduction

Bats

Survey of Bats Conducted at the NASA Plum Brook Station in Sandusky and the Glenn Research Center in Cleveland, Ohio.

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ABSTRACT: Distribution, diversity and relative abundance of the *Chiropterans* (bats) of NASA Plum Brook Station in Sandusky and the Glenn Research Center in Cleveland Ohio were studied from April through September 2001. Methodology included visual and acoustical surveying of the grounds and buildings, the mist netting of wooded, riparian and open sites and radio tracking selected bats within the Stations. Eight species of bats totaling 238 were captured at 17 of the 21 mist net sites at NASA Plum Brook Station in Sandusky. This included an Evening Bat, *Nycticeius humeralis*. Three species totaling six bats were captured or located acoustically at NASA Glenn Research Station in Cleveland. Captures occurred at one of the 8 mist net sites.

Several maternity colonies were located utilized by three different species at Plum Brook Station. Foraging patterns were identified via radio-telemetry. A breeding or courtship area used by Big Brown Bats, *Eptesicus fuscus,* and Red Bats, *Lasiurus borealis* was also located.

INTRODUCTION

The objective of this study was to survey the bats, locate their roost sites and attempt to determine foraging patterns at NASA's Plum Brook and Glenn Research Stations. The secondary objective was to document the presence of any federal or state listed bat species using the NASA Stations for roosting or foraging. Each of the NASA Stations will be addressed in separate sections.

Bat populations in Ohio have been surveyed to a limited degree. "Despite their abundance, wide distribution, and great diversity, bats are among the least studied of all Mammals" (Belwood, 1998). This lack of knowledge is due in part to the fact that, they are small, secretive, nocturnal and silent to the unaided ear. Traveling by flight greatly restricts sampling opportunities as well. Of the 45 species of bats in United States, Ohio is home to ten species plus a questionable historical record of a Small-footed Bat, *Myotis leibii* (possibly a Michigan record).

The ten bats of Ohio are all predators of night flying insects and use echolocating capabilities to exploit this food source. One Ohio species**, Rafinesque's Big-eared Bat**, *Corynorhinus rafinesquii* is very rare and possibly accidental in Ohio. There have been two records for Ohio. Both were along the Ohio River in Adams County and both wintering in caves and both were pre 1961. (Belwood, 1998) The Federally Endangered **Indiana Bat**, *Myotis sodalis,* has widespread records from throughout Ohio but more concentrated in southwestern Ohio. Recently, a maternity colony was located in southwestern Ohio. (Belwood 1998) The **Evening Bat**, *Nycticeius humeralis,* is rarely encountered in Ohio and is in the process of being considered for state listing. Most records are from southwestern Ohio. The fourth rarely encountered bat in Ohio is the

Silver-haired Bat, *Lasionycteris noctivagans*. This bat is most often encountered when passing through Ohio during migration.

The other six species are encountered to a greater degree. The **Little Brown Bat**, *Myotis lucifugus,* is one of the more common bats and encountered statewide. Their maternity colonies can be located in buildings, tree hollows and under the exfoliating bark of trees. The **Big Brown Bat**, *Eptesicus fuscus,* is also a more common bat with a statewide distribution. Their maternity colonies are in buildings and tree hollows. The **Northern Long-eared Bat**, *Myotis septentrionalis,* is an uncommon bat with a statewide distribution. Roost and maternity sites are mostly under exfoliating bark and in tree cavities. The smallest Ohio bat is the **Eastern Pipistrelle**, *Pipistrellus subflavus,* which Dr. Belwood lists as rarely encountered in Ohio (Belwood, 1998). Roosts and maternity colonies appear to be in hollows of trees, caves, rock crevices and even reported roosting under porch eaves. (Belwood, 1998) The **Red Bat**, *Lasiurus borealis,* is a solitary tree (foliage) roosting bat with a statewide distribution. Dr. Belwood lists it as being rarely encountered in Ohio. (Belwood, 1998) Red bat females do not come together to raise their young in maternity colonies but instead roost singly with their young in the foliage of trees and shrubs. The last Ohio bat specie is the **Hoary Bat**, *Lasiurus cinereus*. It is the largest bat occurring in Ohio and like the Red Bat it is a foliage roosting bat. Its distribution is throughout Ohio but is uncommon. Sexes appear to be segregated in summer, with the males being more limited to the western states.

Bats serve as important indicators when surveying the health of an environment. This is in part due to the their reliance on both terrestrial and aquatic habitats, their sensitivity to human disturbance and their sensitivity to low levels of pesticides and pollutants. These chemicals are taken up by way of the bat's insect diet and accumulate in their body fat. Studies have shown that there is an increase in bat mortality that occurs at critical times such as hibernation, migration and weaning of young when these fat tissues breakdown. (Fenton, 1992). The intense level of agriculture surrounding NASA Plum Brook and the probable high use of insecticides the bat populations are potentially at high risk for chemical poisoning.

Part 1
NASA Plum Brook Station

NASA Plum Brook Station, approximately 5,400 acres in size, lies in Oxford and Perkins townships of Erie County, Ohio. This region is known as the Ohio Lake Plain. The habitats encountered include the numerous buildings varying in degrees of current usage, extensive roadways, mowed areas, open old field situations, scrubby, middle and late successional stages of woodlands. Added to these terrestrial habitats, is the network of intermittent streams, several ponds, wet season swamp and marsh areas. These provide for a variety of niches that bats can occupy.

SURVEY METHODOLOGY

Fieldwork was conducted at NASA Plum Brook from April through September 2001. The entire area inside the perimeter fence excepting the part sectioned off at the Reactor Facility was surveyed. The bat survey involved several steps and methods. These included questioning of staff personnel, visual evaluation, acoustic monitoring, trapping, inspection of buildings for bat usage and radio-telemetry. Knowledge of the bat's roosting and foraging activities is essential to a study that requires capture of the animal for the purpose of identification, aging and reproductive assessment.

On Site Interviews: Members of the security patrol, the maintenance staff and Amy Bower in charge of Safety and Quality were interviewed about any sightings of bats or bat guano within the buildings at the station. Members of the night shifts for the security patrol were questioned about sightings of bats in flight.

Visual Evaluation of Site: Preliminary work involved a visual evaluation of the habitats at Plumbrook. This was to identify potential bat foraging corridors that could be mist netted for the purpose of capturing resident bats. Plum Brook Station was divided into six sections **(Figure 1)**; the northern, the western, the central, the eastern edge, the

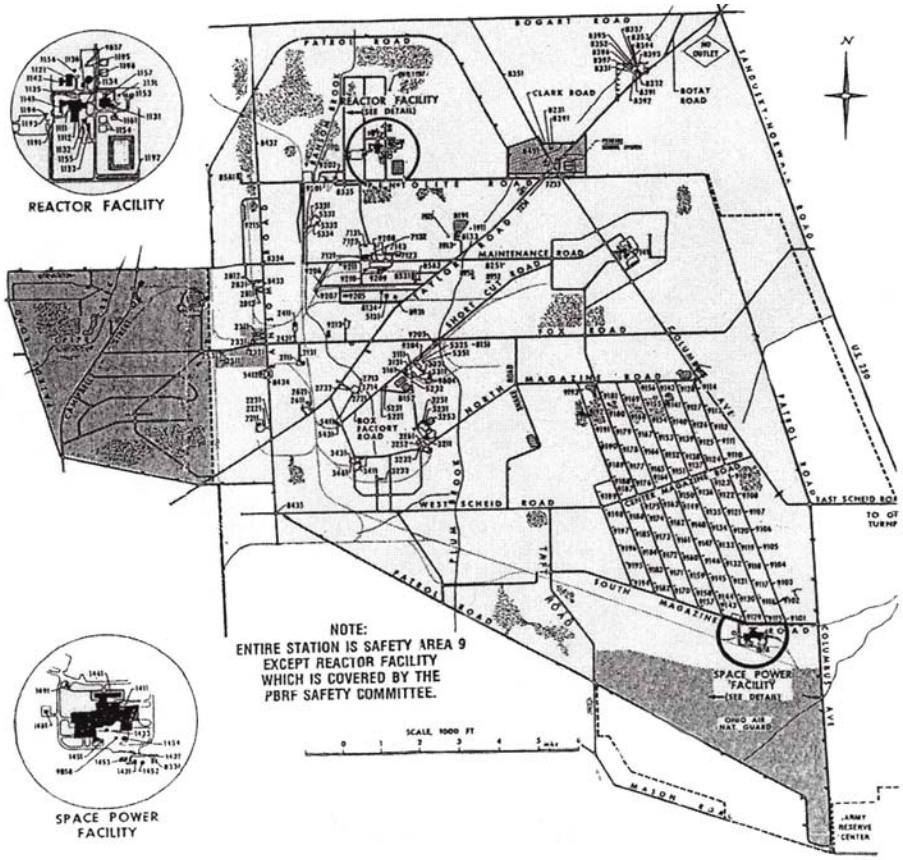

Figure 1; NASA Plum Brook Station – Sandusky, Ohio

bunkers and the Ohio Air Guard areas. The northern section was defined as being inside the Patrol Road and north of Pentolite Road. The western area's boundaries contained the Patrol Road and west of Ransom Road. The central area's boundaries included south of Pentolite Road, east of Ransom Road, south to Patrol Road, east to Columbus Road but excluding the Bunkers and Space Power Facility. The eastern edge area was bordered on the north and east by the Patrol Road, on the south by South Magazine Road and on the west side by Columbus Road. The Bunker area was west of Columbus Road, south of North Patrol Road, east of the western Bunker Road and north of South Magazine Road but including Space Power Facility. The sixth area is the Ohio Air Guard grounds and located in the southeastern section south of South Magazine Road and west of Columbus Road, north of Patrol Road and east of Taft Road.

These areas were checked for suitable stream corridors, roadways with a closed canopy, ponds, buildings utilized for roost sites and forest openings. Scott D. Grindale and Mark Brigham's results suggest small forest openings may offer opportunities for bats to forage and provide orientation points for bats while navigating at landscape level". (Grindal and Brigham, 1998) They found that bat activity actually increased after a road was created. These corridors only functioned when the forested areas adjacent remained.

Woodlands, woodland openings, stream corridors and other wetland areas were examined for the presence of potential roost trees. Visual evaluations included examining buildings for the presence of bats, or signs of bat usage. Bat roost sites used regularly can have stains around exit and entry points. Piles of guano around or within structures are also indicative of their usage. (Anthony et al. 1981)

Buildings inspected for the presence of bats, access points for bat entry or bat guano included: Buildings 2812, 2831, 2811, 2813, 2311, 2331, 2231, 2221, 2211, 9215, 8561, 8432, 9208, 9209, 7131, 7122, 7143, 8334, 9211, 9212, 9203, 9214, 3161, 3111, 3131, 3161, 9204 and 5131 **(Figure 1)**. Inspections were from the inside where access was available, otherwise from the outside and examining through the windows. The Space Power Facility, Power Plant #1, the Reactor Facility, Box Factory Road complex, the Recreation Center and a single room un-numbered "check station" building in the western section were also inspected.

Acoustic Monitoring: Bats produce high frequency sounds used in a process called echolocation. This sensory system assists them when flying the darkness to avoid obstacles and assist in locating food. These ultrasonic vocalizations were monitored with a "Bat Box II" bat detector by "Stage Electronics".

Beginning at dusk, the roadways at Plum Brook were driven, stopping and listening at pre-selected points. The bat detector was used to check around buildings, ponds, marshes, woodlands and stream corridors. Additionally it was used to detect the bat's foraging areas and their periods of foraging. The detector was also used at net site locations to monitor bat activity within the vicinity of the nets.

Visual Emergence Counts: Potential roost sites both natural and man-made were checked at dusk for bats emerging for a night of foraging activity. One or more observers placed in positions where they can backlight flying bats against the sky can tally individuals exiting or entering the roost." (Thomas, D. W., 1988)

Buildings 8532, 9201, 9202, 9205, 8562, 9204, 3111, 3131, 3161, and 9214 were checked at dusk. The Space Power Facility and Bunkers 9101 and 9102 were also checked at dusk for emerging bats **(Figure 1)**. Potential roost trees as well as roost trees located with radio-telemetry were also checked.

Mist Netting: Otherwise elusive bats can be effectively captured with mist nets for the purpose of identification. Mist nets were set at 21 selected riparian, woodland and open sites **(Figure 2)**. At these sites nets were spread over the waterways, forest clearings and across roadways. Net patterns included single nets, nets in a series, in a "L" shape, as well as sets of two nets high (double canopy) and sets of three nets high (triple canopy).

Black ATX, 4 shelf, 12 X 2.6meter nets with 36mm mesh were used. A maximum number of 65 nets at 21 locations were utilized during the course of the trapping. Seventeen different nights of mist netting were done between April 28 through September 29, 2001.

Each net site was netted for no more that two consecutive nights, followed by a period of several days before the next sampling attempt. This avoided the "phenomenon known to anyone netting or trapping the same site over successive days as the regular decline in the catch rate with time." (Knuz and Brock, 1975) The increased level of disturbance can cause the bats to abandon their foraging area and bias interpretation of life history information.

Figure 2; Stretching mist net.

Nets were spread at dusk, checked at regular intervals and were closed as bat activity dropped off because of the time or temperature. "Constant attendance at a net is important, since some bats are able to chew themselves out within minutes, often leaving gapping holes." (Kunz, 1988)

Each bat was removed from the nets **(Figure 3)**, was placed in a muslin holding bag. The capture time and site was recorded. Records were kept as each bat was identified to specie, sexed, aged, reproductive condition assessed and banded with an aluminum split ring numbered band **(Figure 4 and Figure 5)**. Bats were released within the hour after capture.

At times attempts were made to lure bats into the nets by holding an already captured bat and allowing it to vocally "squeak". The swarming response can result in additional captures
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Figure 3; Bat Capture in mist net.

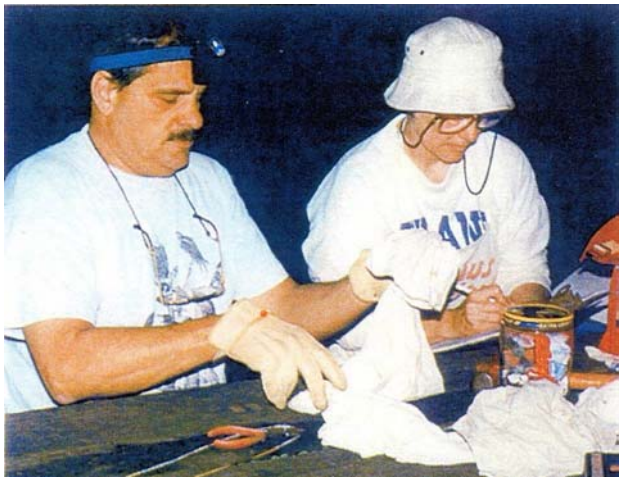


Figure 4;Recording identity, age and sex.

Figure 5; Banded bat.

Figure 6; Bat with radio transmitter

Radio Telemetry: Obtaining information on bats is particularly challenging due to their nocturnal and aerial habitats. Radio-transmitters with whip-style antennas were applied to three individuals of different species **(Figure 6)**. Tracking of these individuals assisted in determining foraging patterns, time of activity periods and locating roost sites.

Rare species or representative females that were lactating (actively nursing) were tracked. This was to determine locations of maternity colonies. Maternity or nursery colonies are roosts where females of some bat species congregate in numbers to give birth and raise their young. These can be located in hollow trees, buildings, under loose or exfoliating bark, in the foliage of trees or below ground.

Holohil Systems Ltd. (Canada) manufactured the transmitters. The mass of the transmitter was kept below 5% of the bat's body mass. (Cochran, 1980). The transmitter was glued to the bat's hair on its back with cyanoacrylate glue ("Krazy Glue"). This ensured that the transmitter would fall off after a certain time interval even if the bats do not get captured again.

A 1.2 gram BD-2 Transmitter with a frequency of 164.278 was attached to a lactating female Big Brown Bat (*Eptesicus fuscus)*. A 0.48g. LB-2 Transmitter with a frequency of 164.168 was attached to a lactating female Eastern Pipistrelle Bat (*Pipistrellus subflavus*). Another 0.48g. LB-2 Transmitter with a frequency of 164.211 was attached to a lactating female Evening Bat (*Nycticeius humerali*s).

The tracking equipment included a TRX-1000S Receiver, a 3-Element Folding Yagi Antenna **(Figure 7)** and an Omni-directional Car Top Antenna from Wildlife Materials of Carbondale, Illinois. The bat's roost sites were then located and the timing and location of the bat's foraging activities were determined through triangulation.

Figure 7; Yagi antenna.

Age, Sex and Reproductive Assessment: It is difficult to assign accurate ages to animals taken from the wild. Bats are long-lived for mammals of their size. Little Brown Bats, *Myotis lucifugus*, have been know to exceed thirty years and Big Brown Bats, *Eptesicus fuscus*, over fifteen years. For the purpose of this survey individuals were placed into one of two broad age groups, juveniles or adults.

Juvenile bats were distinguished from adults by using the Epiphyseal-Diaphyseal Fusion method (Barbour and Davis, 1969). By back lighting the bat's spread wing and viewing the phalanges to determine if the epiphyseal plates were still cartilaginous, as in a juvenile or if they had ossified as in an adult. As a secondary method, pelage color was examined in the *Myotis* genus.

The presence of a conspicuous penis in male bat facilitates sex identification. Pelage differences with the *Lasiurus* genus was also used for gender distinction.

During the first two thirds of the season females were evaluated to determine if they were pregnant, activity lactating (nursing), or post lactating, with the nipples having become keratinized. The nipple morphology was used with adult female bats as the criterion for parity (Pearason et a. 1952).

The species of bats that reside in Ohio all mate in late summer or early fall. Late August and into September reproductive activity in females was determined by the presence of a mucus plug at their vagina. Reproductive activity was determined in captured males by the swollen testis and/or a red hemorrhaging at the tip of their penis.

RESULTS

On site Interviews: Interviews with security and maintenance personnel did not result in a significant gain in information about the locations of bat roosting sites. Security personnel were able to provide some information about bats foraging at the lights at the Main Gate.

Visual Evaluation of Site: The visual evaluation of Plum Brook for suitable corridors for mist netting resulted in a number of suitable sites **(Figure 8)**. Suitable sites in the northern section were found along Ransom Brook just south of Patrol Road as well as along Reactor Facility Road see Mist Net Results. There were some wooded swamps to the east of Ransom Brook but these dried up early in the season and were not netted. The western area provided the greatest number of suitable corridors. These were sections

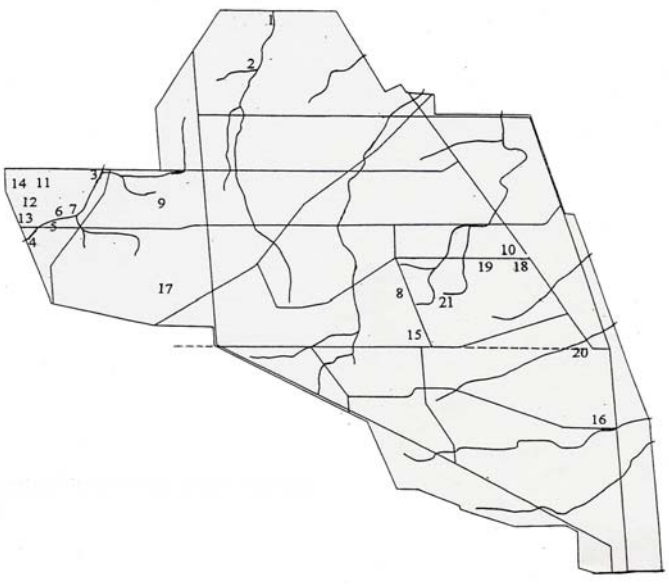


Figure 8; Mist netting site at Plum Brook Station.

along Pipe Creek with closed canopies **(Figure 9)**. One site was as the creek entered the station from the west and another was where the creek exited the station to the north. The third was in the creek corridor in the vicinity of West Area Red Water Ponds (referred to in this report as Twin Ponds). The dike separating Twin Ponds **(Figure 10)** was selected as a net site as well as nets placed over the water of both the smaller eastern pond and the larger western pond **(Figure 11)**. Potential roost trees of exfoliating bark were found north of the western pond, see Visual Emergence Counts.

Figure 9; Closed canopy of Pipe Creek.

Figure 10; Dike between Twin Ponds.

Figure 11; Western Twin Pond.

Figure 12; Unnamed road in western section. Western

Other spots identified in the section included the woodland corridor across an unnamed road in the southeastern part of this section **(Figure 12)**, see site 17 in Mist Net result section. Mowed paths encircling the Recreation Center's round containment pond were also identified as potential net sites.

The openness and the number of buildings in the Central Area resulted in few potential netting areas. The only sites suitable were along Snake Road, south of North Magazine Road. The pond along the west side of the road and a large Shagbark Hickory near its banks selected as well as a section of Snake Road with a closed canopy just north of West Scheid Road.

The Eastern Edge Area with its lack of wetlands or closed canopy roadways did not provide any netting sites. The Bunker Area with several sections of the road with closed canopies **(Figure 13)** and several small ponds did provide for a number of potential netting sites.

Figure 13; Closed canopy in Bunkers.

The mowed open areas of the Ohio Air Guard section resulted in not selecting any netting sites. The western part of it was too brushy to effectively net and the pond was also too open to net.

Access gained to some locked buildings with Amy Bower of Safety & Quality resulted in finding the presence of Bat Guano indicating that there had been some bat activity in Building 9202 prior to April 21, 2001.

This activity was likely from the previous year. When the building was re-checked on August 23 no new activity was evident. Access to buildings 9201, 9205, 9207, 5131 and 8931 did not result in finding any signs of bat activity.

Because of a significant amount of bat activity just at dusk in the vicinity of Bunkers 9101 and 9102 entry was gained to see if bats were roosting inside. These bunkers were also checked to see if they might function as winter hibernacula due to their subterranean characteristics. With a lack of entry points into these structures neither was the case. Some of the vent tubes projecting out of the ground may be used as daytime roosting sites but inner grids prohibited bats' access into the bunker.

Positive use of buildings by bats included:

1. A brick pump house west of Campbell Street in the western section resulted in the capture of a roosting female **Northern Long-eared Bat, *Myotis septentrionalis*,** April 21. The bat was inside in an upper dark corner. The pump house was checked several other times during the course of the study without any additional captures.

2. April 21 bat guano was found in Building 9212 in the western section of Plumbrook Station. This white barn-like structure is partially overgrown with trees **(Figure 14)**. Bats have access through broken out windows, holes in the sides and roof and an open barn door. Bats were observed flying in the

building at 11:50pm the night of May 5. On May 27 over **12 *Myotis*** species were found roosting adjacent to a central cupola. Additionally two Little Brown Bats, *Myotis lucifugus*, were found at dusk July 14.

Figure 14; Building 9212.

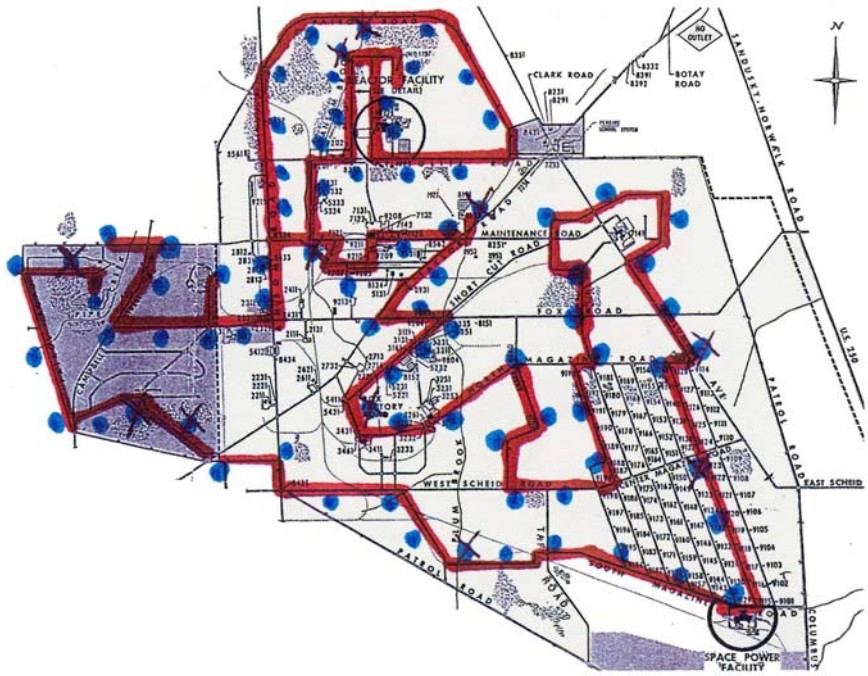
Figure 15; Building 9214.

3. The inspection of a red barn on Campbell Street, building 9214 **(Figure15)** resulted in one Big Brown Bat, *Eptesicus fuscus,* on July 14. At dusk, August 17 **two bats were observed flying** in the immediate area but not visibly exiting the building.

4. Radio-telemetry located a colony of bats using building 8532, see discussion under Radio-telemetry and Visual Emergence Counts sections.

Acoustic Monitoring: The results for the route driven listening with the bat detector at pre-selected sites are shown in **(Figure 16)**. The red line indicates the route driven, blue dots indicate where listening with the bat detector took place. An "X" on a blue dot indicates where high frequency sounds from bats were detected. Out of the 81 listening sites 11 had bats foraging.

Figure 16; Route for acoustic monitoring.



This information assisted in the net site selection. Two sites where bats were detected did not provide suitable sites for net placement and were not further sampled. One was the Box Factory area and the other was where Plum Brook intersects south Patrol Road.

Visual Emergence Counts: During the course of the fieldwork a total of six bat colonies were identified at Plumbrook Station.

1. Using radio-telemetry a Maternity Colony was found in building #8532 in the western section. The colony was located in exterior scaling concrete of the former power plant **(Figure 17)**. Emergence counts results:

Building 8532;emergence counts

Date	Time Period	Emergent Total
July 12	9:15–9:50pm	48
August 17	8:40-8:50pm	69
September 8	7:57-8:10pm	54

This colony comprised mostly of Big Brown Bats, *Eptesicus fuscus*, but also included the radio-tracked Evening Bat *Nycticeius humeralis*. Bats emerged from two different openings on the western face. Bats were never observed roosting inside of the building.

Figure 17; Building 8532
Big Brown and Evening Bats

Figure 18; Dead Elm north of Twin Ponds containing Pipistrelle colony.

2. July 10 a maternity colony was found in a dead Elm (*Ulnus* sp.) 50 yards north of the western twin pond **(Figure 18)**. Over 50 bats were observed exiting from several openings in the exfoliating bark of a15 inch diameter tree. All the bats observed emerging were small in size. Their flight was slow with a lot of twisting and turning. According to Dr. Belwood Pipistrelles are among the fist bats to emerge in the early

evening, foraging at tree top level. They are "characteristically slow, erratic, fluttery flight and small enough to be mistaken for a moth." (**Belwood, 1998)**.

Nets were set up near colony to capture and positively identify the specie (net site #14). Bats were observed steering and avoiding the nets placed 10-15 feet away from the openings. Nets placed at the pond's edge, in the direction traveled by the emergent bats, captured three bats. All three were nursing Eastern Pipistrelles, *Pipistrellus subflavus* (net site #13).

3. Another colony was located along the wood's edge in a group of dead Elm's also with exfoliating bark **(Figure 19)**. This site was located 75 yards to the east of the previous site. An accurate count was not made (25+) at this location but with the emergence flights observed these bats appeared to be in the genus *Myotis.*

Figure 19;Elm- *Myotis* colony location.

Figure 20; Pipistrelle colony.

4. July 11 an Eastern Pipistrelle, *Pipistrellus subflavus*, was radio-tracked to a roost site in the woods 60 yards west of Campbell at a point where Pipe Creek is turning to the north. The roost site was in an eighteen inch diameter tree 20 yards east of where Pipe Creek turns north **(Figure 20)**. This colony was high in the canopy of a live tree. There were no cavities or exfoliating bark observed in this tree.

On July 14 a total of 23 bats were observed exiting this area between 9:03 and 9:25pm. Because of the thick foliage it was difficult to accurately determine the total number of emerging bats. The radio-tagged bat left the roost site visually undetected. When checked on July 17 the radio-tagged Pipistrelle was roosting in a tree 50 meters to the west.

5. On July 14 in the vicinity of Bunker 9102 a group of 15 – 20+ Eastern Pipistrelles were also observed emerging from that wooded area. A triple canopy was erected in that location on July 20.

6. July 28 the area around Bunker 9102 was checked for emerging bats. None were detected coming from the bunker. At dusk over 25 Red Bats, *Lasiurus borealis,* were observed emerging from the oak trees just north of the bunker. Examination of the ground under some of the Oak Trees (*Quercus sp.*) found guano scattered around. Red Bats are foliage roosting bats, hanging by day among the leaves of the tree.

7. May 27 Building 9212 contained a cluster of 12 Little Brown Bats, *Myotis lucifugus,* roosting inside adjacent to the central cupola.

Mist Netting: Determined by visual and acoustical inspections, a total of 21 net sites were established **(Figure 8)**. These consisted of a combined total of 68 net sections set in various arrangements and totaling an effort of 1062.45 net hours **(Table 1)**

TABLE 1. Net site location and description.

Site No.	Site Location	Site Description	No. of Nets	Net Shape
1	Ransom Brook North	Wooded seasonal stream corridor south of Patrol Road.	2	Single nets across stream. 100 feet apart
2	Ransom Brook South	Wooded seasonal stream corridor north of Reactor Facility Road.	2	Single nets across stream. 80 feet apart
3	Pipe Creek North	Wooded stream corridor south of Patrol Road	2-3	Single and double canopy nets across stream 200 feet apart.
4	Pipe Creek West	Wooded stream corridor west of Patrol Road	2	A single net across stream and a single net in an "L" shape 100 feet
5	Pipe Creek at Twin Ponds	Wooded stream corridor south of Twin Ponds	1-3	Single nets across stream corridor
6	Twin Ponds Double Canopy	Wooded dike between Twin Ponds	4	Two lengths of double canopy nets set in a series.
7	Eastern Twin Pond	Wooded temporary pond	1	Single net across eastern pond
8	Snake Road Pond	Partially wooded pond	1	Two single nets in series across southern part. Two nets in "V" shape along north shore.
9	Recreation Center	Mowed paths around recreation center pond.	2	Two single nets 50 feet apart on mowed paths adjacent to brush.
10	Pond at N. Magazine and Columbus Rds.	In grasses along shore of pond.	4	Two sets of two single nets in a series. One along east and other along west shoreline
11	Western Twin Pond Shoreline	Along northeastern shore in tall grasses.	1	Set parallel to shore.
12	Western Twin Pond over water	Extending out over water north central edge adjacent to snag	1	Extending from shore out over water.
13	Western Twin Pond over water	Over water in western basin.	9	Two double canopy nets in series, two sets of two single nets in "L" shapes
14	Pipistrelle Colony	In open woods with several exfoliating trees.	2	Double canopy 10 feet from tree with colony
15	Snake Road	Snake Road 100 yards north of West Scheid Road.	2	Across road in wooded corridor
16	Bunker 9102	Wooded section north of Bunker 9102	3	Triple canopy across bunker road in wooded section.
17	Royal Fern	Un-named road in western section 1500 feet N.W. of intersection of Patrol & S.W. end of Taylor Rds.	2	Double canopy across road in mature woods
18	Bunker 9114 Pond	Along the south shore of pond and across road	3	Three nets in a series.
19	Bunker 9142 pond	Along south shore in partial woods	3	Nets set in a series along shoreline.
20	Columbus Road Pond	Wooded pond west of Columbus Road just north of bend for West Scheid Road (abandoned)	1-5	Single nets across water surface, double canopy along east shore.
21	Bunker 9190	Wooded section of bunker road north of #9190	2	Double canopy across road.

Mist netting was done on 22 different nights resulting in 238 captures **(Table 2)** The captures represented eight different species **(Table 3)**.

Table 2. Comparison of mist netting effort to the number of bats captured by date.

Sample Date	No. of Sites	No. of Nets	No. of Bats	Net/ Hours	No. of Sites Bats Caught
Apr. 28	4	7	0	17.5	0
May 5	7	14	7	77	6
May 27	3	8	1	26	1
June 8	5	14	6	35	2
June 17	4	8	4	46	3
June 29	8	18	16	103.5	5
July 1	5	10	4	30	2
July 6	6	11	3	34.5	1
July 8	6	17	3	102	1
July 10	4	15	6	71.25	2
July 14	3	7	3	31.5	2
July 20	7	24	20	156	6
August 2	5	13	9	54.5	3
August 3	7	17	13	102	5
August 17	8	22	10	141	4
August 22	4	13	18	39	3
August 30	3	10	30	21.75	3
September 3	3	10	28	48.5	3
September 8	5	22	55	73.5	4
September 29	3	10	0	30	0

Table 3. Number of bats caught by specie.

Bat Species	Common Name	No. Caught
Eptesicus fuscus	Big Brown Bat	102
Lasiurus borealis	Red Bat	65
Myotis lucifugus	Little Brown Bat	27
Myotis septentrionalis	N. Long-eared Bat	26
Pipistrellus subflavus	Eastern Pipistrelle	11
Nycticeius humeralis	Evening Bat	1
Lasiurus cinereus	Hoary Bat	1
Lasionycteris noctivagans	Silver-haired Bat	1
Myotis sp.*		4

**Myotis* sp. are ones that escaped before being able to identify them to specie.

The eight species were the Little Brown Bat *Myotis lucifugus* **(Figure 21)**, Northern Long-eared Bat *Myotis septentrionalis* **(Figure 22)**, Big Brown Bat *Eptesicus fuscus* **(Figure 23)**, Eastern Pipistrelle *Pipistrellus subflavus* **(Figure 24)**, Evening Bat *Nycticeius humeralis* **(Figure 25)**, Red Bat *Lasiurus borealis* **(Figure 26)**, Hoary Bat *Lasiurus cinereus* **(Figure 27)** and Silver-haired Bat *Lasioycteris noctivagans* **(Figure 28)**.

Fig. 21; Little Brown Bat

Fig. 22; N. Long-Eared Bat

Fig. 23; Big Brown Bat

Fig. 24; E. Pipistrelle

Fig. 25; Evening Bat with Big Brown Bat

Fig. 26; Red Bat

Fig. 27; Hoary Bat

Fig. 28; Silver-haired Bat

Of the twenty one net sites, five sites did not result in any captures **(Table 4)**. Of the sixteen sites that did, Site 20 made up 50 % of the overall captures, Site 5 made up 15.96%, and Site 6 made up 11.76%. The other sites each were 5% or lower. Not all sites were netted the same number of nights **(Table 4)**.

Table 4. Number of bats caught per net site.

Trap Site	No. Bats Caught	No. of Nights Netted
1	1	2
2	0	1
3	5	8
4	4	6
5	38	15
6	28	14
7	6	8
8	1	3
9	0	1
10	0	1
11	0	4
12	3	3
13	3	2
14	0	1
15	2	2
16	12	8
17	5	4
18	4	4
19	3	3
20	119	5
21	2	3

Radio Telemetry: Radio-transmitters were applied to three bats, two that were females showing signs of actively nursing and one male. The nursing females included a Big Brown Bat, *Eptesicus fuscus* and an Eastern Pipistrelle, *Pipistrelles subflavus*. The male was an Evening Bat, *Nycticeius humeralis*.

1. On July 10, at 9:30pm, an Eastern Pipistrelle was captured at Site 6 **(Figure 8)**. The bat was an adult lactating female. A LB-2 radio transmitter was activated and applied to its back. It produced a steady pulse at Frequency 164.168 ("Bat 168"). It was released at 12:45am (July 11) at the capture site **(Figure 29, point 1)**. It flew southeast of the Twin Pond area and remained foraging

At 2:25pm on July 11 "Bat 168" was located roosting high in a tree with no visible cavities **(Figure 29, point 2)**. July 12 "Bat 168" was roosting in same location. July 14 "Bat 168" left its roost at 9:30pm and traveled northwest and foraged **(Figure 29, point 3)**. July 17 "Bat 168" was located roosting in a tree 60 yards to the west of previous roost **(Figure 29, point 4)**. July 20 "Bat 168" was roosting in same area and emerged to forage 9:05pm and foraged to the south and east of the roost site **(Figure 29, point 5)**. The signal was noticeably weaker and by July 24 there was no signal.

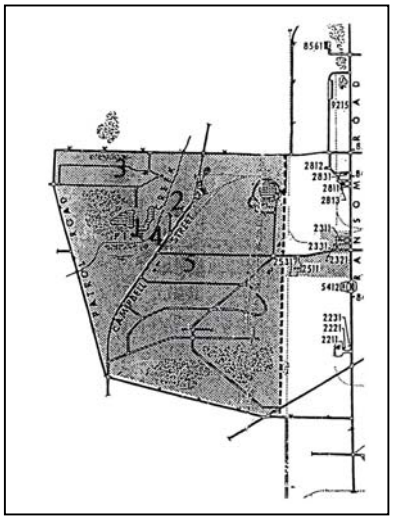


Figure 29; Radio-tracking and maternity colony locations for "Bat 168", *Pipistrellus subflavus.*

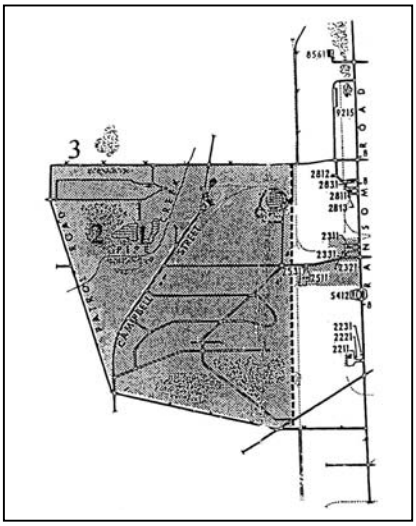


Figure 30; Radio-tracking of of "Bat 278", *Eptesicus fuscus*

2. On July 10 at 10:45pm a Big Brown Bat was captured at Site 5 **(Figure 8)**. This was also an adult lactating female bat. A BD-2 radio-transmitter was applied to its back and activated. Its signal, Frequency 164.278, was irregular at first but became steadier with time. "Bat 278" was released at 12:45am (July 11) **(Figure 30, point 1)**. She remained in the area of the western Twin Pond and then headed north **(Figure 30, points 2 and 3)**. "Bat 278" was never heard from again. Areas were extensively checked both day and night throughout the Station and the outside surrounding are up to 10 miles away.

3. On July 10 at 11:05pm an adult male Evening Bat was captured at Site 6 **(Figure 8)**. A LB-2 radio-transmitter was activated and attached to his back. It produced a steady pulse at Frequency 164.211 ("Bat 211"). "Bat 211" was released at 12:45am (July 11) at the capture site and landed on the ground **(Figure 31, point 1)**. It was then placed on the trunk of a tree where it remained and began to enter a state of torpor. It was still there when checked at 1:30am.

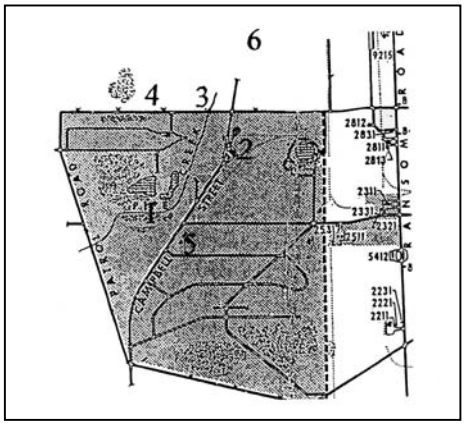


Figure 31; Radio-tracking and roost location for "Bat 211", *Nycticeius humeralis.*

At 2:50pm July 11 "Bat 211" was located in a crack in the western outer wall of Power House Building 8532 **(Figure 31, point 2), (Figure 17)**. July 12 "Bat 211" left its roost site at 9:35pm and traveled west towards Twin Ponds. After foraging near the ponds and to the north over Pipe Creek north **(Figure 31, point 3)** it returned to the roost at 10:30pm. July 14 "Bat 211" was roosting in the same crack in Building 8532, later it was foraging to the north outside Plum Brook station **(Figure 31, point 4)**. July 17 "Bat 211" was again roosting in building 8532. July 20 by 9:45pm "Bat 211" was foraging to the southeast of Twin Ponds **(Figure 31, point 5)**. At 1:40am July 21 its signal, now significantly weaker, was coming from outside the Station, north on Campbell Street **(Figure 31, point 6)**. July 24 no signal was detected.

Age, Sex and Reproductive Assessment: For the captured bats the number of females and males for each species and the composition of adults to juveniles is given in **Table 5.**

Table 5. Number of males compared to females and adults to juveniles for each specie.

Bat Species	Total	Male	Female	Adult	Juvenile	Unknown
Eptesicus fuscus	102	50	42	80	12	10
Lasiurus borealis	65	35	16	31	20	14
Myotis lucifugus	27	12	15	25	2	
Myotis septentrionalis	26	12	14	24	2	
Pipistrellus subflavus	11	4	6	9	1	1
Nycticeius humeralis	1	1		1		
Lasiurus cinereus	1		1	1		
Lasionycteris noctivagans	1		1	1		

The result from assessing the reproductive activity for females is presented in **Table 6.** For males by the August 30 sampling time reproductive activity became apparent with swollen testis and/or red hemorrhaging at the tip of the penis. By the September 8 sampling time 43% of the Red Bat males examined showed obvious signs of being reproductively active. In Big Brown Bat males 38% showed signs. The individuals showing mucus plugs, swollen testis and red hemorrhaging at the tip of their penis were captured predominantly at Site 20.

Table 6. Reproductive assessment for captured female bats at Plum Brook Station.

Bat Species	No. Females	Pregnant	Lactating	Post Lact.	Mucus Plug	Reproductively Inactive
E. fuscus	42	1	7	14	12	8
L. borealis	16			1	2	13
M. lucifugus	15	1	5	9		1
M. septent.	14	3	6	4	1	
P. subflavus	6		5			1
L. cinereus	1		1			
L. noctivag.	1			1		

DISCUSSION OF RESULTS

The mist netting effort, shown as Net Hours in **Table 7**, did not directly influence the number of bats captured. Time of the year, locations being sampled and weather

conditions all played a part in the capture success. **Table 7** shows that later in the year the number of captures increased

Table 7. Comparison of Mist netting effort and sampling time to capture success.

Date	No. Captures	Net/ Hours
April 28	0	17.5
May 5	7	77
May 27	1	26
June 8	6	35
June 17	4	46
June 29	16	103.5
July 1	4	30
July 6	3	34.5
July 8	3	102
July 10	6	71.25
July 14	3	31.5
July 20	20	156
Aug. 2	9	54.5
Aug. 3	13	102
Aug. 17	10	141
Aug. 22	18	39
Aug. 30	30	21.75
Sept. 3	28	48.5
Sept. 8	55	73.5
Sept. 29	0	30

The greatest number of captures came in the later part of August and early September. This pattern is due to the increase number of bats flying now that the young of the year have become volant. Not only are there more individuals but the increase in captures is the result of the inexperienced young being more apt to fly into the mist nets.

The collection of eight different species at Plumbrook Station is very significant. The only potential bat that could also be found there is the Federally Endangered Indiana Bat, *Myotis sodalis*. As stated in the introduction the tenth Ohio bat Rafinesque's Big-eared Bat, *Corynorhinus rafinesquii,* if to be encountered, would be in extreme southern Ohio.

The most significant individual collection made during this survey was the Evening Bat, *Nycticeius humeralis.* Most records for this bat in Ohio are from the southwestern part of the state. The solitary sample was radio-tagged and followed for several days (see radio-telemetry discussion).

The only record for all of Canada is from Point Pelee National Park in 1911. This peninsula is directly north across Lake Erie from Plum Brook Station. To the east in Pennsylvania, Evening Bats are recorded in the extreme southwestern part of the state. The closest Ohio record is an individual taken in the Killbuck Marsh Area (southern Wayne Co.) in the summer of 2000. Otherwise it is listed as rarely encountered in Ohio (Belwood 1998).

In the southeastern United States where it is more abundant it is considered a true forest bat that roosts in hollow trees, behind loose bark and sometimes in buildings. Maternity colonies are sometimes with the Big Brown Bat, which is very similar in appearance. Measurements of the forearm and an inspection of the bat's dentition were made to distinguish it. Also the size difference was noted, see **Figure 25**.

Another significant record was the Silver-haired Bat, *Lasionycteris noctivagans.* This bat probably represents a migratory individual rather than a summer resident. It is more commonly encountered in the northern forests of Canada in summer and in the Southern States in winter. In migration it is still rarely encountered in Ohio. Silver-haired Bats are solitary roosters under loose bark or in tree cavities.

The number of individuals, the presence of lactating females **(Figure 32)** and the identification of maternity colonies of Eastern Pipistrelles, *Pipistrellus subflavus*, is extremely noteworthy. Because they forage at treetop level, capturing them is more difficult than some of the other bat species. I feel that the percentage of their captures is not representative of their population size at Plum Brook.

Figure 32; Lactating Eastern Pipistrelle, *Pipistrellus subflavus.*

The observation of emerging Pipistrelles in the vicinity of Bunker 9102 on July 14 indicates that more sampling work needs to be done in that area. The establishing a canopy net at that location on July 20 was probably too late to accurately sample this region or locate a Maternity site. In the work done in southern Indiana John Whitaker found that Pipistrelles leave their summer breeding sites and begin appearing the entrances to mines by July 25 (Whitaker, 1998). Only two Pipistrelles at Plum Brook Station were caught later than this, they were on August 2 and 4 **(Appendix).**

There is a significant lack of knowledge about Pipistrelles and roost site selection. As shown by the radio-tagged Pipistrelle there seems to be roost site switching. Whitaker found that this takes place whether or not young are present in the colony (Whitaker, 1998). Winter hibernacula include mines and caves and are usually less than 100 miles from their summer sites. The mines and caves to the west in Ottawa and Seneca Counties are potential destinations of the Plum Brook bats.

The presence of the lactating Hoary Bat is a strong indication that the young are being reared in the mature forests of Plum Brook. Hoary Bats are solitary, foliage roosting bats that Dr. Belwood lists as rarely encountered in Ohio (Belwood 1998).

The mature woods and the adjacent pond encountered in the vicinity of the Columbus Road and the old East Scheid Road served as an important courting and mating ground for both Red and Big Brown Bats **(Figure 33)**. This was indicated by the reproductive condition of the captured bats and the observed flight activities. The males were in breeding condition as indicated by swollen testicles and the number with red tips of their penis as a result of copulating. Several of the females had mucus plugs indicating they had already copulated as well.

Figure 33; Columbus Rd. pond -important Red Bat, *Lasiurus borealis* and Big Brown Bat, *Eptesicus fuscus* courting and breeding ground.

Observed flight patterns of the bats in this area were often two or three bats chasing each other. This was also detected with the Bat Detector. Their preoccupation with mating may have also led to increase captures. Not only was this area being used as an important mating area, guano scattered on the ground under the foliage indicated it was functioning as a day roosting area as well.

For a number of Ohio bat species the mating frenzy usually takes place at the entry point to their hibernacula. Mating then takes place just before they enter to hibernate. Red Bats are believed to migrate south and therefore do not have a hibernacula entryway to concentrate their numbers and provide place for courtship and mating. Bats from a widespread area converge onto these critical and isolated staging areas.

Red Bats were the second most frequently capture bat **(Table 3)** at Plum Brook. Their captures were not just limited to the Columbus Road pond but significant numbers

were also taken from the western area as well. As a bat that Dr. Belwood lists as rarely encountered in Ohio this is a significant population that is probably dependent on the more mature wooded tracts on the Station.

RECOMMENDATIONS

The bat populations at NASA Plum Brook are good and efforts should be to maintain them. The potential for also encountering the Federally Endangered Indiana Bat, *Myotis sodalis,* is fairly high given the physio-graphic conditions, the Station's size and the population of Northern Long-eared Bats, *Myotis septentrionalis.* Foster and Kurta found in southern Michigan both these bats occupy similar niches and compete directly or indirectly for roosting sites **(Foster and Kurta 1999)**.

Callahan et.al, found that the "ecology of Indiana Bats in summer indicated that following hibernation females migrate north to predominately agricultural regions to give birth and raise their young" **(Callahan et. al, 1997)**. NASA Plum Brook currently provides for the ideal combination of structural roosting areas and adjacent agricultural areas.

The stability of bat populations is dependent on an abundant and safe source of food and safe roosting places. Even with the intensity of the agricultural activity surrounding Plum Brook and the probable significant use of chemicals, including insecticides it does not seem to have caused the number of bats to decline. This may be that the size of the Station is large enough to make the bat populations "self-sufficient" and they are not venturing out of it to forage. At this time Plum Brook is supplying a variety of safe roost sites as shown by the diversity of bats inhabiting it and the level of reproductive activity occurring.

In order to insure the continuation of these bat population I recommend the following:

1. Maintain old buildings for maternity and day roost sites. Williams and Brittingham found that Big Brown Bats, *Eptesicus fuscus*, typically selected older and taller buildings, and often with galvanized steel roofs **(Williams and Brittingham, 1997)**. The Power Plant and Building 9212 in the western section are both critical for the Little Brown, Big Brown and Evening Bats.
2. Leave the standing dead trees especially those in the vicinity of Twin Ponds. Those adjacent and in the wet areas throughout the station and those along road and wood edges should be left intact. In a recent study Callahan et al. found that "all primary roosts for the Federally Endangered Indiana Bats, *Myotis sodalis,* were in standing dead trees exposed to direct sunlight, alternate roosts included both living and dead trees that were typically in the shaded forest interior **(Callahan, et al. 1997)**. These trees will continue to be utilized by both Little and Northern Long-eared Bats, *Myotis lucifugus and M. septentrionalis.*
3. Maintain the open areas in the vicinity of Twin Ponds, Snake Road pond, the Recreation Center, and intermixed within the Bunker Area. A study done by Grindal and Brigham found that small disturbances resulting in forest

openings, like building a roadway, provided foraging and orientation advantages to insectivorous bats when the bulk of the forested areas remain intact.

4. Maintain the wildness of the numerous small permanent and vernal wetlands.
5. Maintain the wooded riparian corridors, both trapping and acoustical monitoring showed these to be extremely important foraging corridors. Once they dried up, like Ransom Brook did the bats moved to other locations to feed.
6. Avoid spraying of insecticides or herbicides on the grounds
7. Monitor and maintain the water quality in the wetlands.
8. Inspect the buildings for bat usage and limit disturbance during critical times at the buildings being used.
9. Consider setting aside some Bunkers for potential hibernaculas for wintering bats.
10. Allow more re-forestation to occur around some of the central areas especially around pond sites.

Part 2
NASA Glenn Research Center Cleveland

By comparison NASA's Glenn Research Station in Cuyahoga County and adjacent to Cleveland Hopkins Airport is smaller, considerably more developed resulting in a limited area of habitat suitable for bat usage. The ravine formed by Abram Creek with its slopes of mature forest including Eastern Hemlock, Oak, Maple and Beech trees provides a suitable corridor for foraging and potential roosting sites for bats.

The age, level of usage and construction of the buildings did not provide for roosting sites for bats. Open spaces were neatly mowed thus not suitable as foraging sites or collecting sites. The high level of human and machine activity from the Center and adjacent airport all added to the limited usability for bats.

Because the Center had an Indiana Bat survey conducted in 1999. It was decided that effort would not be as great as originally proposed and be focused in the area north of the previous survey. This sampling area included the Abram Creek ravine from the West Area Road south to near the junction of Cedar Point and Creek Roads and the upland forest sites adjacent to it.

SURVEY METHODOLOGY

Fieldwork was conducted on four occasions, a visual inspection on June 12, and sampling on June 22, July 31 and August 25 2001. The survey methodology was similar to that for Plum Brook except no radio-telemetry was incorporated.

On site Interviews consisted of being given a tour of the Center by Richard Kalynchuk and talks with guards at the gate house.

Visual evaluation of the site was conducted with Richard Kalynchuk on June 12 and also the afternoon of June 22. Potential roost and foraging sites were identified and net sites selected.

Acoustic Monitoring was ongoing each collection night. This was done the entire length of Abram Creek in the study area, the adjacent wooded ridges, around the buildings and at the Rocket Engine Test Facility

Age, sex and Reproductive Assessment was as described above in the Plum Brook section.

Mist Netting was done on June 22, July 31 and August 25 at eight sites **(Figure 34)** and followed the same protocol as described in the Plum Brook section. Net patterns include single nets in a series, double and triple canopy net sets. Net size and type were as described in the Plum Brook section.

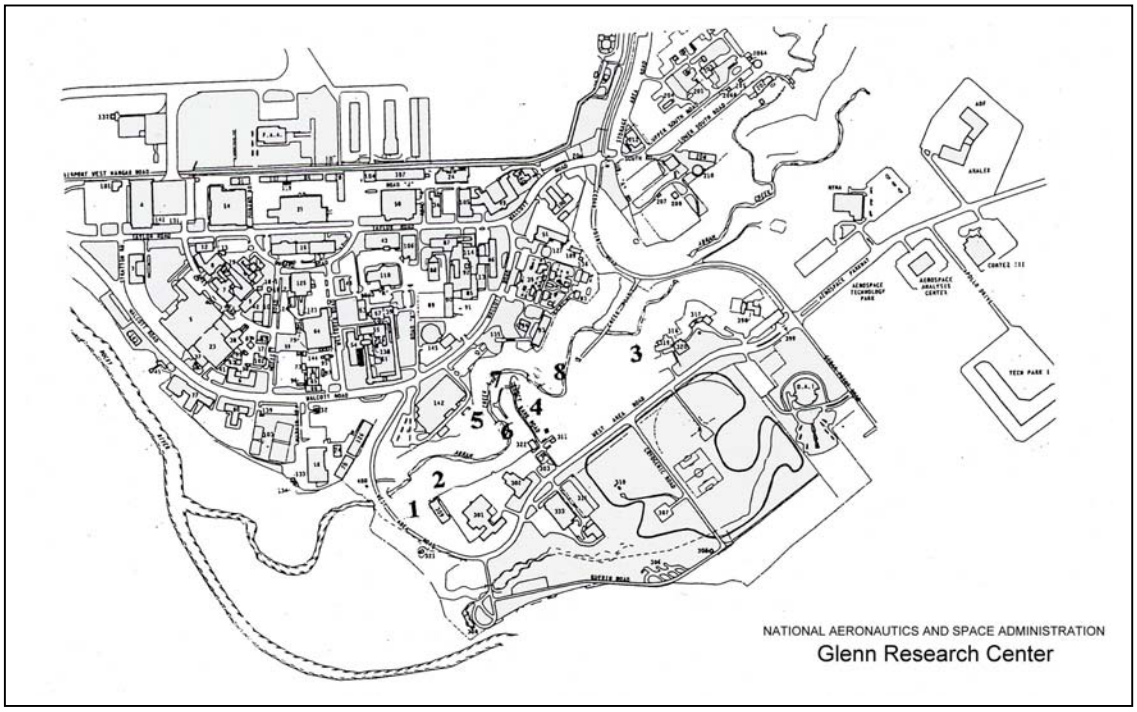


Figure 34; Mist net sites at NASA Glenn Research Center Cleveland, Ohio.

RESULTS

On Site Interviews assisted in gaining access to Abram Creek and locating the few older structures on the Center.

Visual Examination resulted in selecting the following net sites:

Site 1; A double canopy in the wooded ridge top northeast of Space Power Research Laboratory Bldg. 309.

Site 2; Two single nets in a series along the wooded ridge top east of Space Power Research Laboratory, Bldg. 309.

Site 3; Two single nets in a series along the wooded ridge top east of Substation "N", Bldg. 319.

Site 4; Two single nets in a series at the base of the wooded hill side and just east of Duct Bank Road.

Site 5; A double canopy in the woods along Abram Creek and just below Research Analysis Center Bldg. 142.

Site 6; A double canopy across Abram Creek 50 feet down stream of the pipe crossing over Abram Creek and net site 5.

Site 7; Two single nets parallel to each other across Abram Creek 200 feet upstream of the pipe crossing Abram Creek.

Site 8; A triple canopy across Abram Creek 300 yards upstream of site 7.

Acoustic Monitoring June 22 did not pick any sounds of foraging bats. The areas checked throughout the sampling period (9:00pm to 1:30am) included each net site,

the full stretch of Abram Creek in the sample section. Also monitored were the areas in and around the Rocket Engine Test Facility and Bldg. 77, Instrument Research Lab.

On July 31 a *Myotis* species was heard in the vicinity of Net Site 7 at 8:55pm. At 9:10 a Red Bat, *Lasiurus borealis* was heard and seen flying over Abram Creek at Net Site 6. At 10:50pm a Big Brown Bat, *Eptesicus fuscus* was detected and viewed with flashlight at the Rocket Engine Test Facility Bldg. 202.

On August 25 Bats were heard foraging along Duct Bank Road at 8:45, 9:10 and 10:10pm. At 10:55pm a bat was detected acoustically along Abram Creek 40 feet downstream of Net Site 8.

Mist Netting for the three nights had a combined total of 233.75 net/hours for the eight Mist Net Sites. The June and July nights did not capture any bats. August 25 Two bats were captured, both at Net Site 8. At 11:00pm a female juvenile Little Brown Bat, *Myotis lucifugus* was captured. At 11:05pm a male Red Bat, *Lasiurus borealis* was captured but escaped before it could be aged. He was caught in the upper panel of the triple canopy net and chewed his way out before the net was completely lowered. *Note he was sexed by pelage and with the dullness of the color it was probably a juvenile.

The Little Brown Bat was banded with MT 1277.

DISCUSSION OF RESULTS

The Abram Creek ravine, cascading waterfalls and surrounding mature Hemlock and Hardwood forest ridges deceivingly seem pristine and wild in this heavily developed area. With a maximum total of three bat encounters on July 31 and five on August 25 (some of which may have been the same individuals) the bat population at NASA Glenn Research Center is sparse.

On closer examination the water source running through it is void of life. There were no aquatic insects found when examined. Many as adults would have provided a food source for the insectivorous bats. It is possible that the lack of food, the noise from the Center's many facilities and the adjacent airport make it far less habitable for the bats than what they might find in the adjacent Rocky Fork River.

NASA personal indicated that the water quality in Abram Creek is directly related to the amount of de-icing fluid that needs to be applied to the aircraft at Cleveland Hopkins Airport during the winter. The severer the winter the farther into the summer season it takes for Abram Creek to get it all the de-icing fluid flushed out.

RECOMMENDATIONS

If this unique habitat is to become the wild oasis that it has the potential for;

1. The runoff needs to be cleaned or diverted.
2. Noise levels reduced whenever possible.
3. Leave the forest as is, keeping exfoliating, dead and hollow trees intact.
4. Let areas not used "grow wild".

ACKNOWLEDGEMENTS

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